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(54) **HIGH-VOLTAGE AC LED STRUCTURE**

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H05B 37/00 (2006.01)

(52) **U.S. Cl.**
USPC **315/192**; 315/193

(58) **Field of Classification Search**
None
See application file for complete search history.

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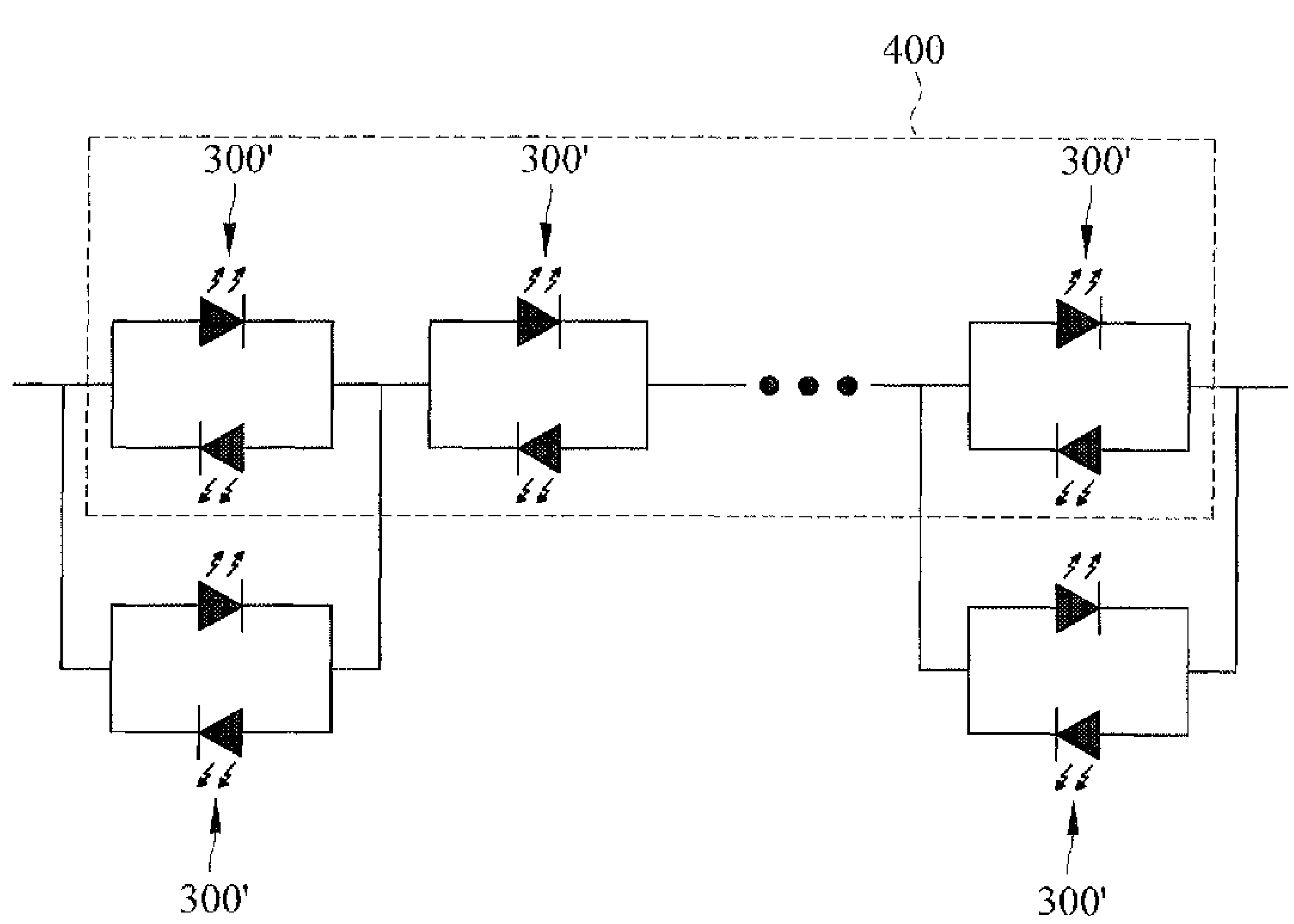
(57) **ABSTRACT**

The present invention provides a high-voltage alternating current light-emitting diode (AC LED) structure. The high-voltage AC LED structure includes a circuit substrate and a plurality of AC LED chips. The AC LED chips each include an insulated substrate, an LED set, a first metal layer and a second metal layer. The AC LED chips manufactured by a wafer level process are coupled to the low-cost circuit substrate to produce the downsized high-voltage AC LED structure.

13 Claims, 10 Drawing Sheets



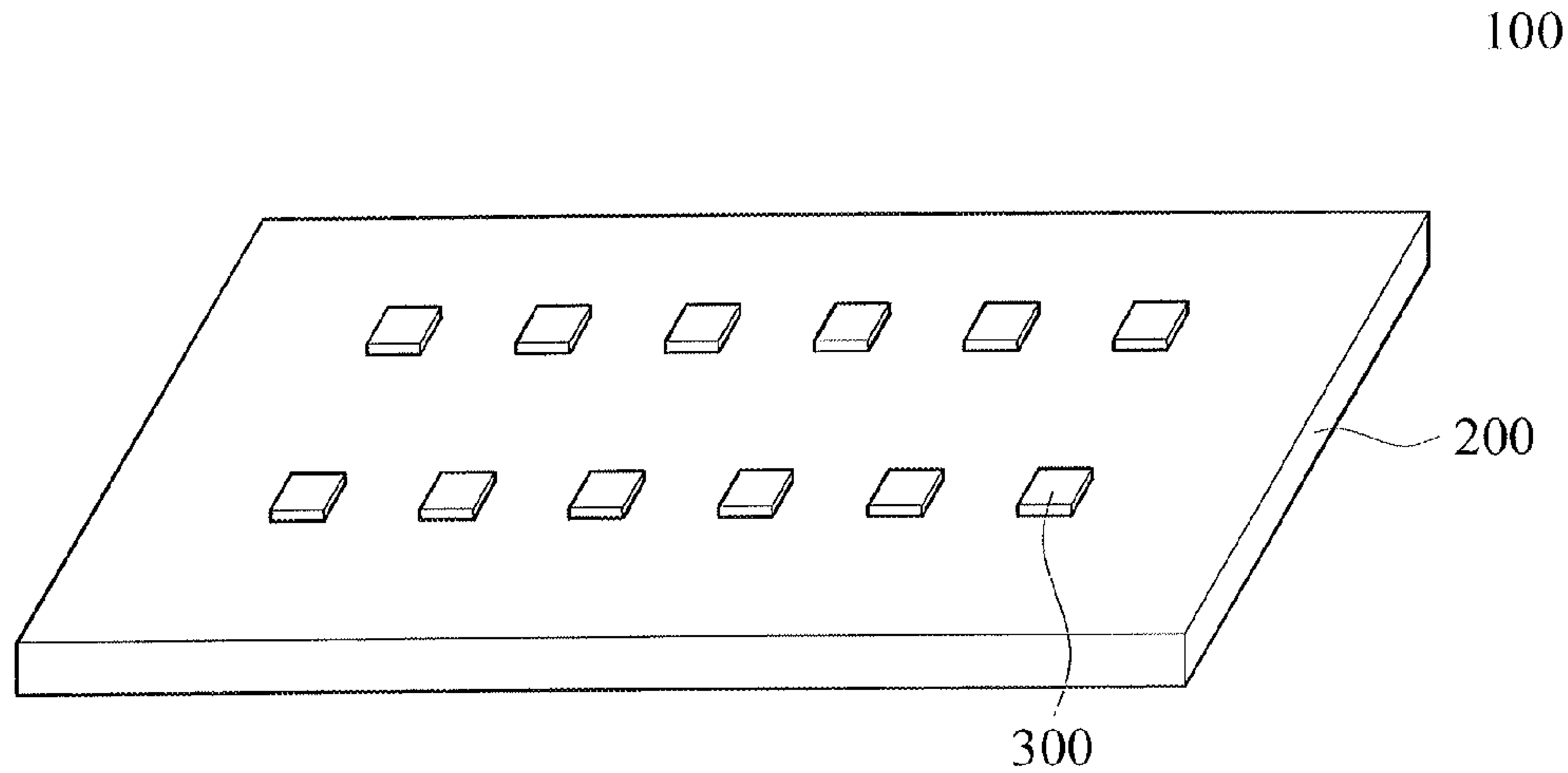


FIG. 1A

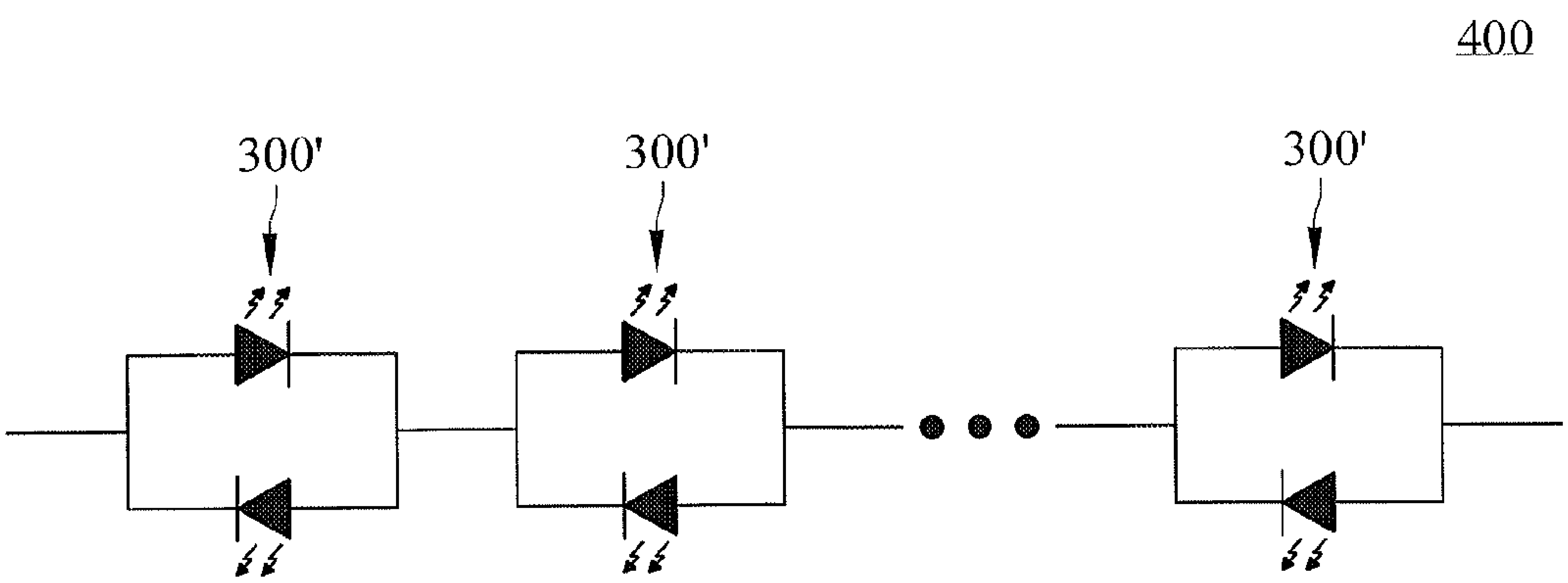


FIG. 1B

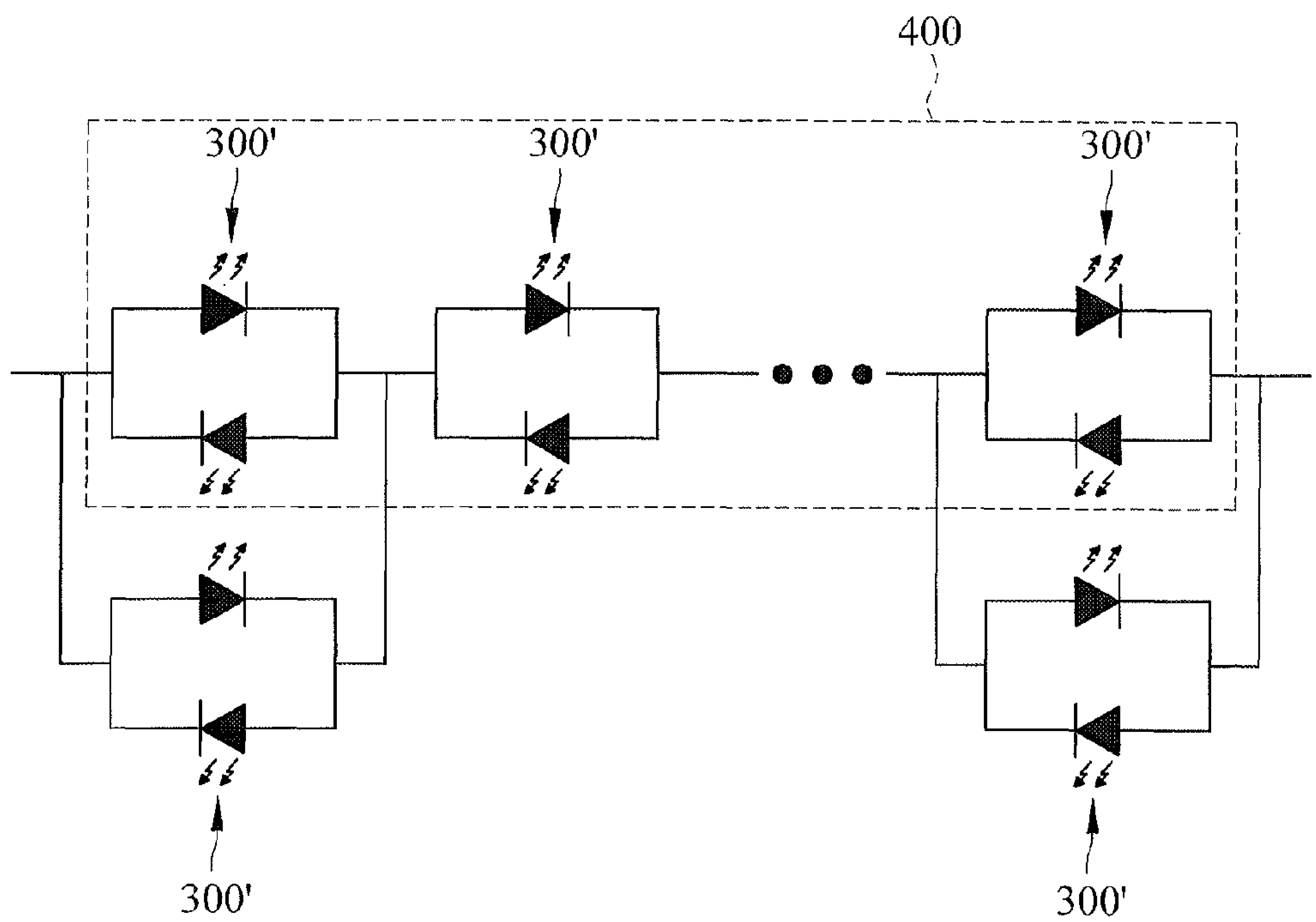


FIG. 2A

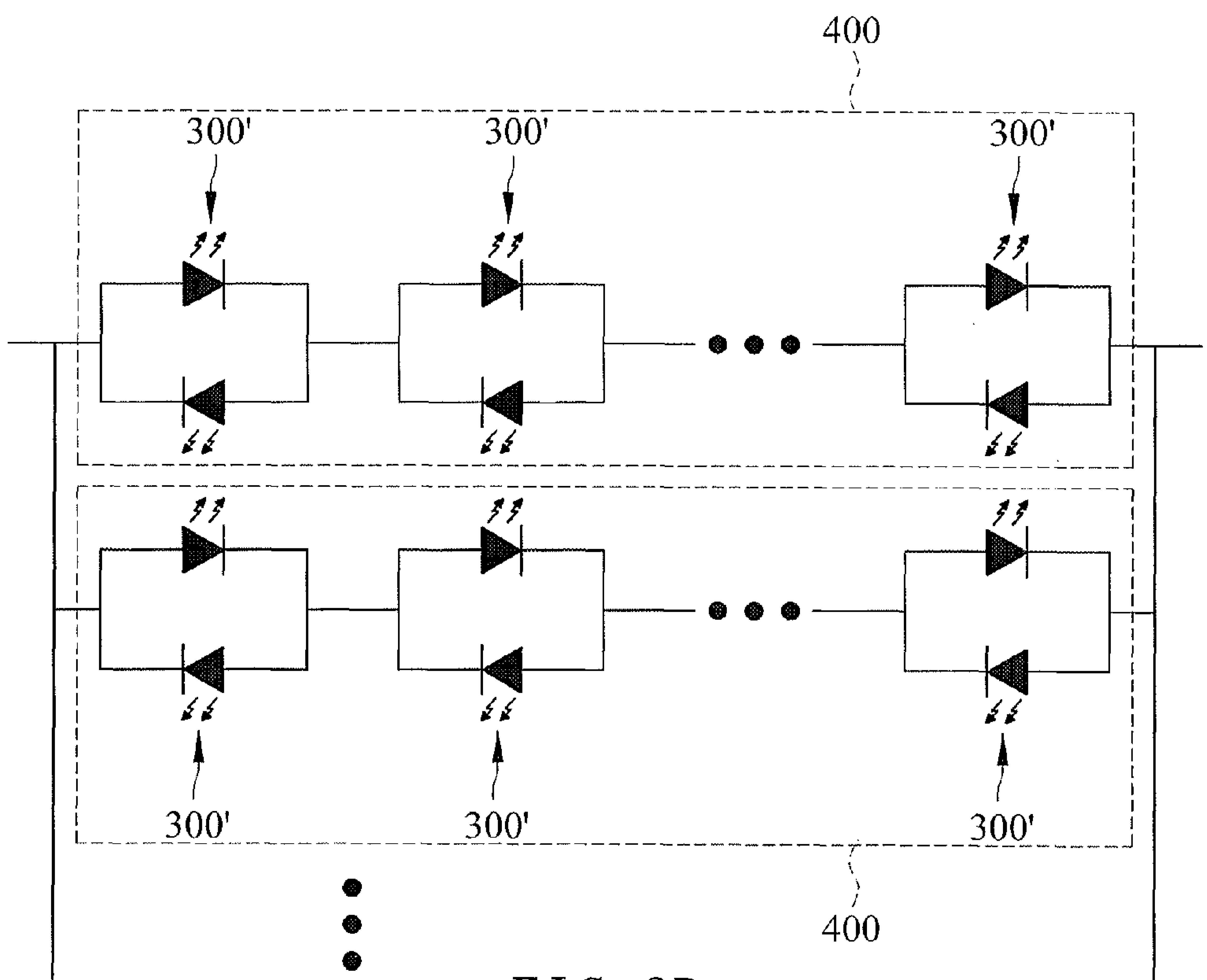
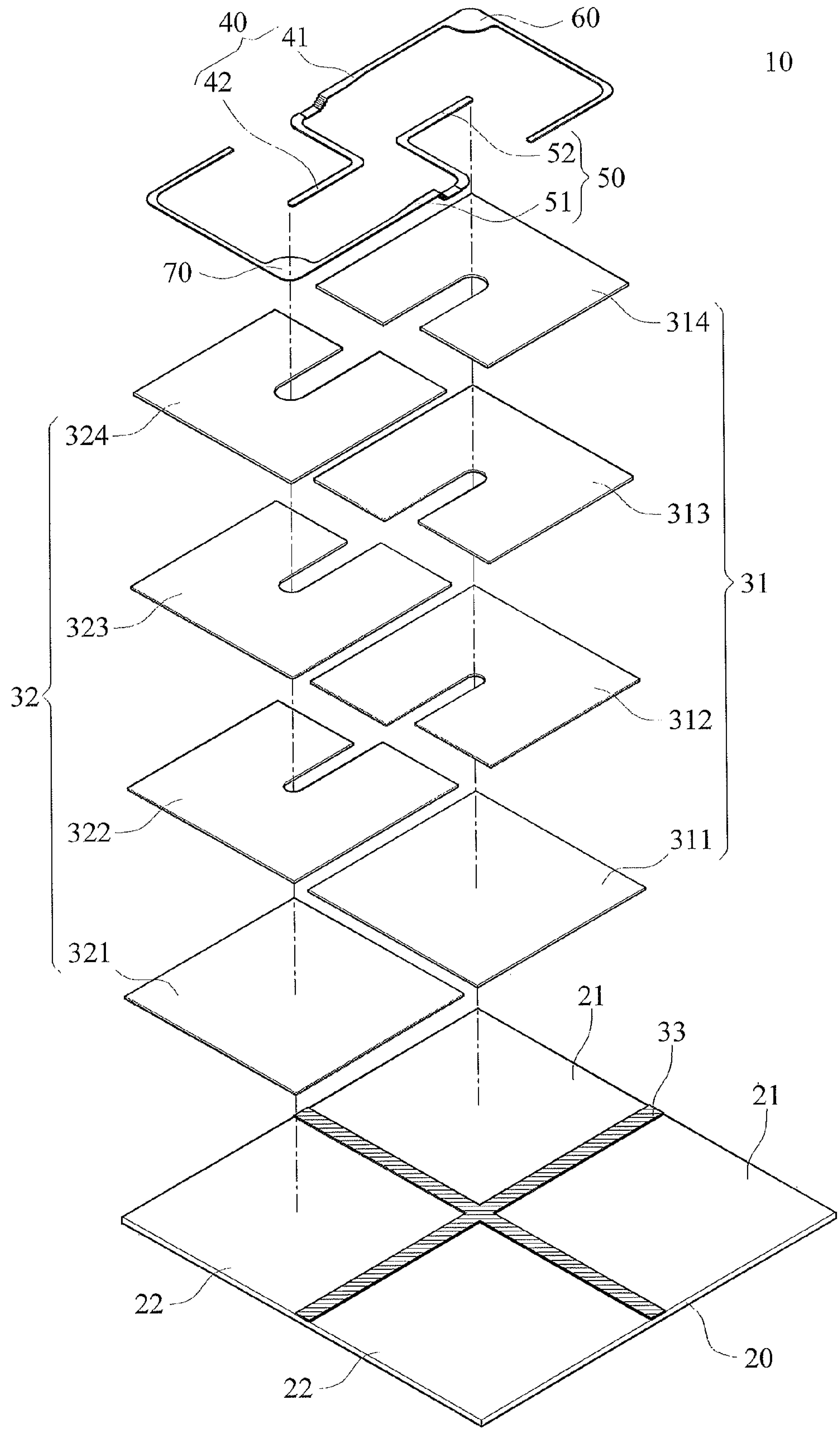


FIG. 2B



40
41
42
60
10
52
50
51
70
314
324
313
31
323
312
32
322
311
321
21
33
21
22
22
20

FIG. 3

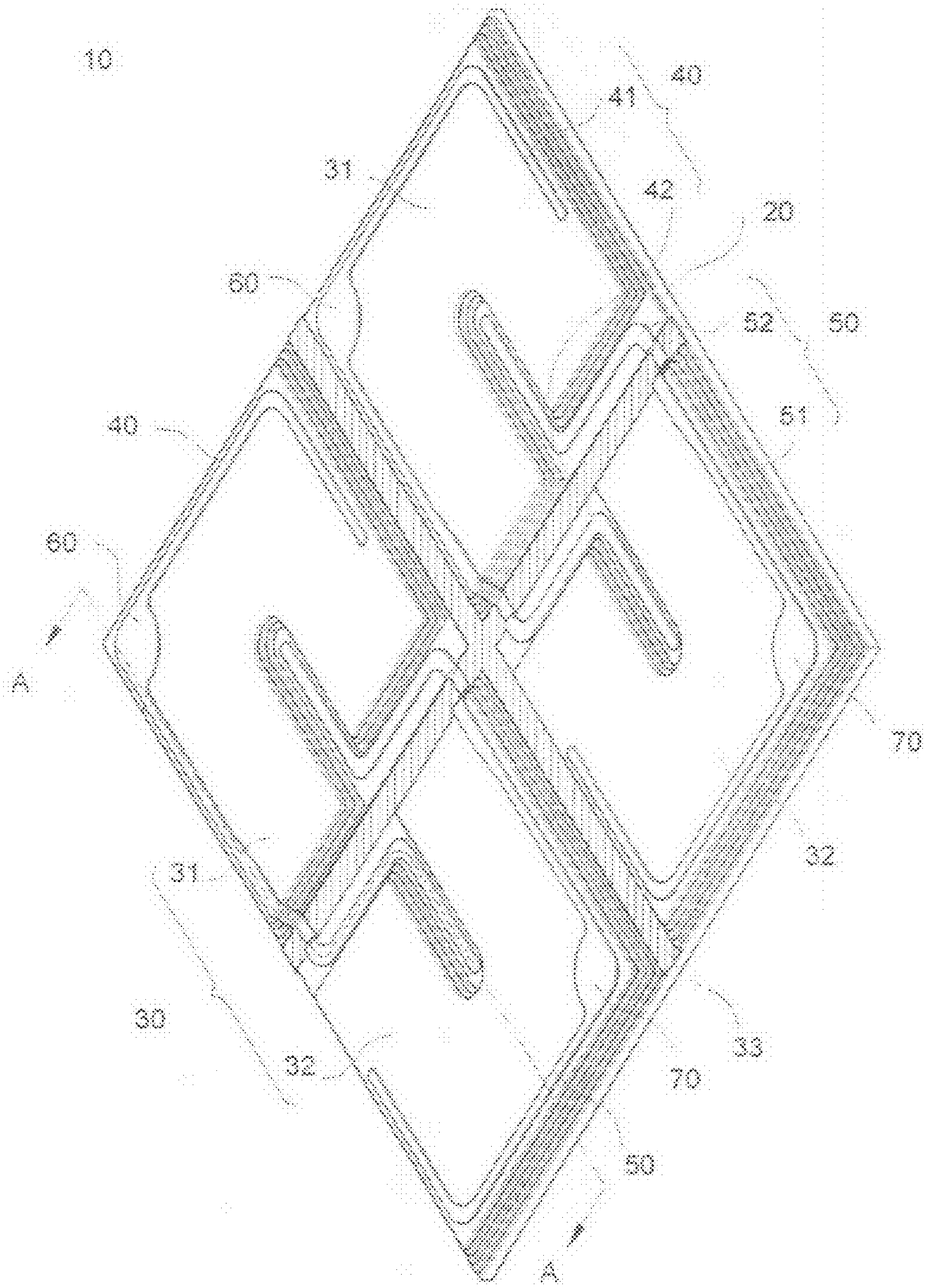


FIG. 4A

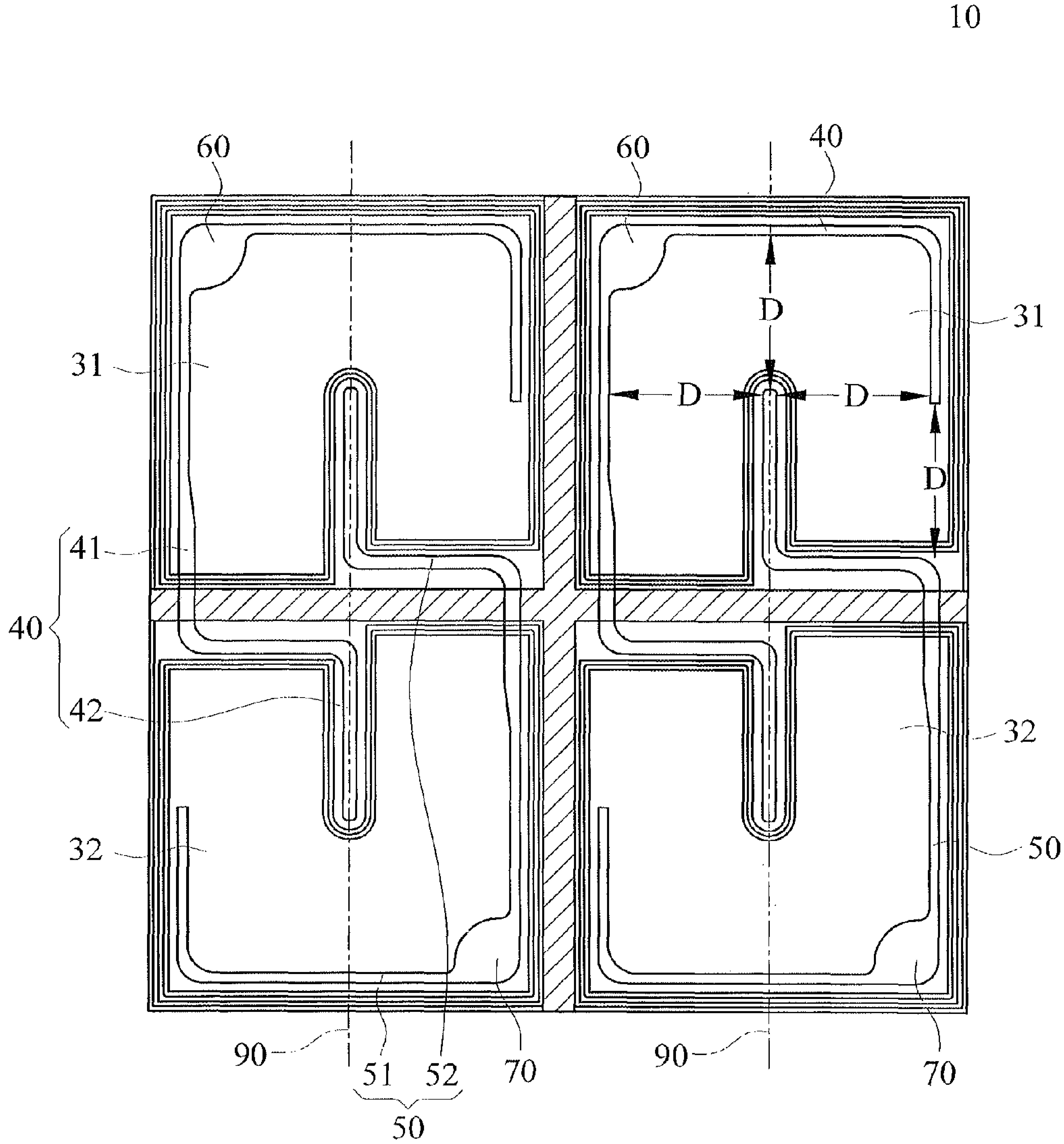


FIG. 4B

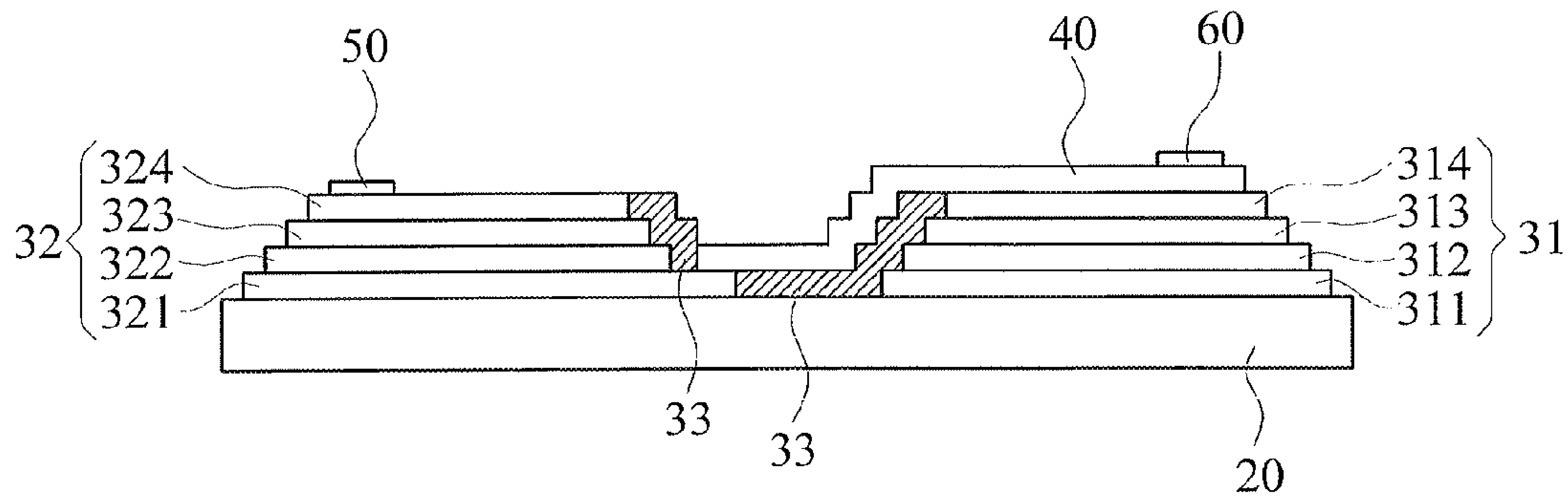

50
40
60
324
323
322
321
32
314
313
312
311
31
33
33
20

FIG. 5

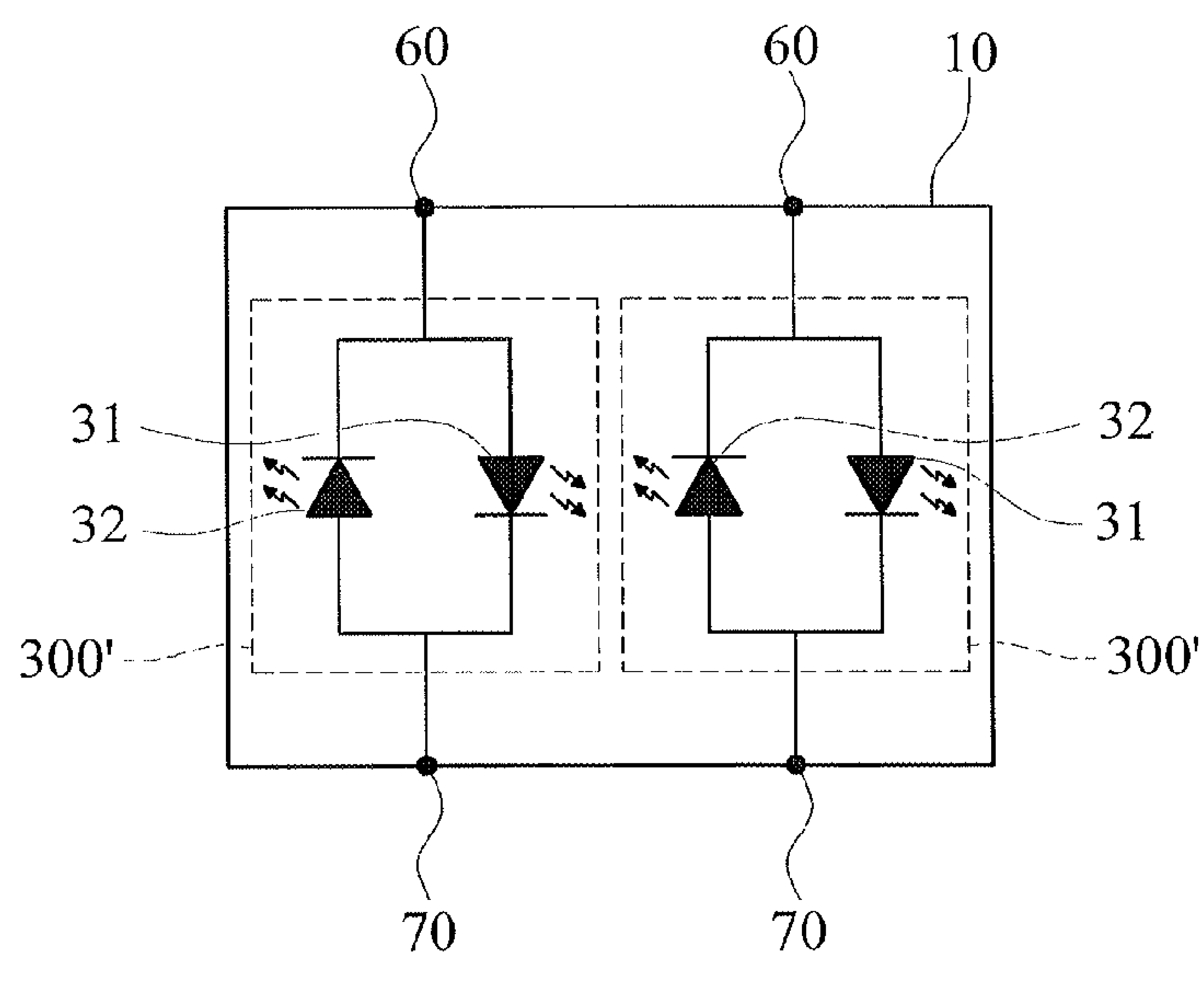

60
60
10
31
32
32
31
300'
300'
70
70

FIG. 6

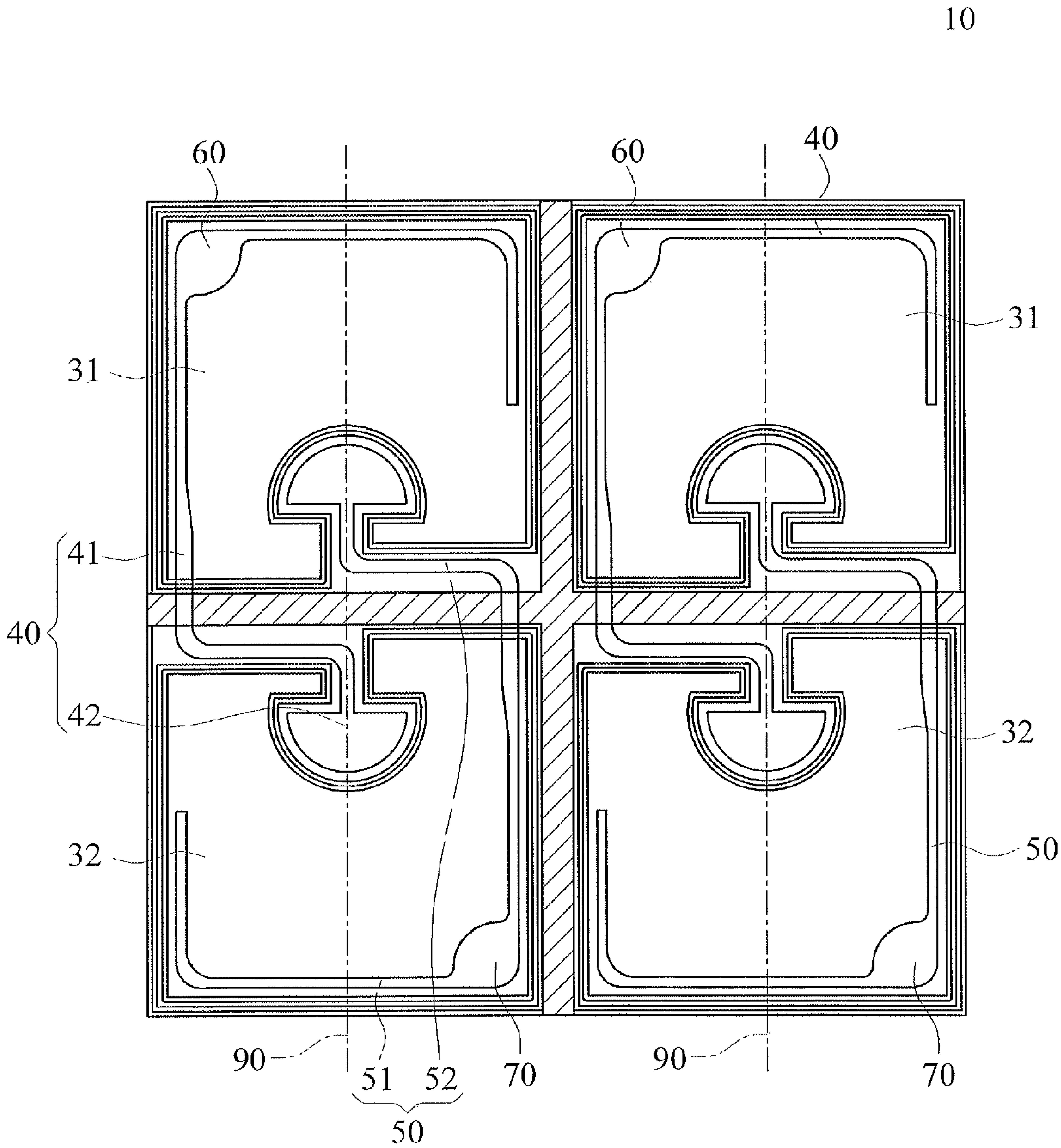


FIG. 7

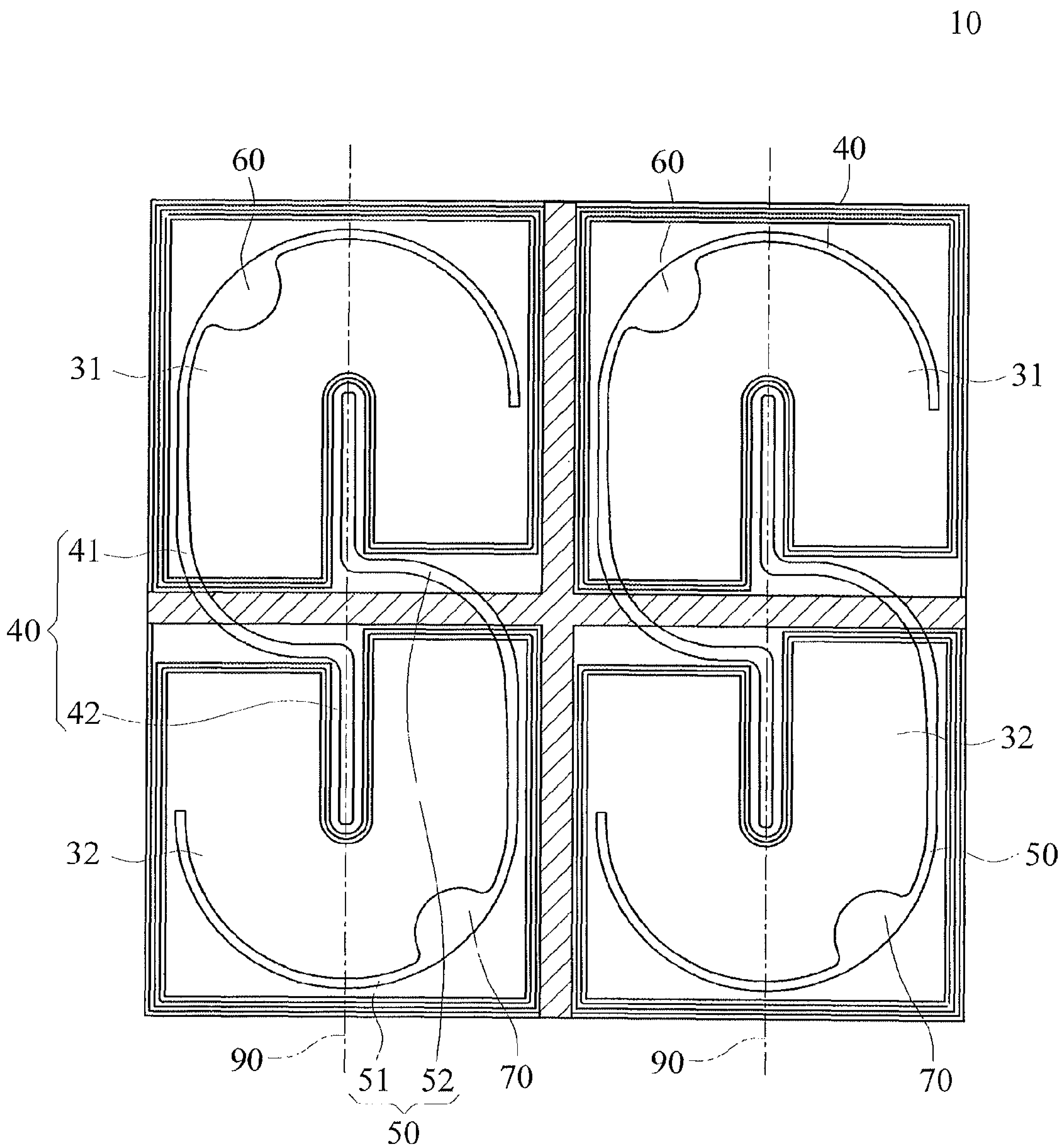


FIG. 8

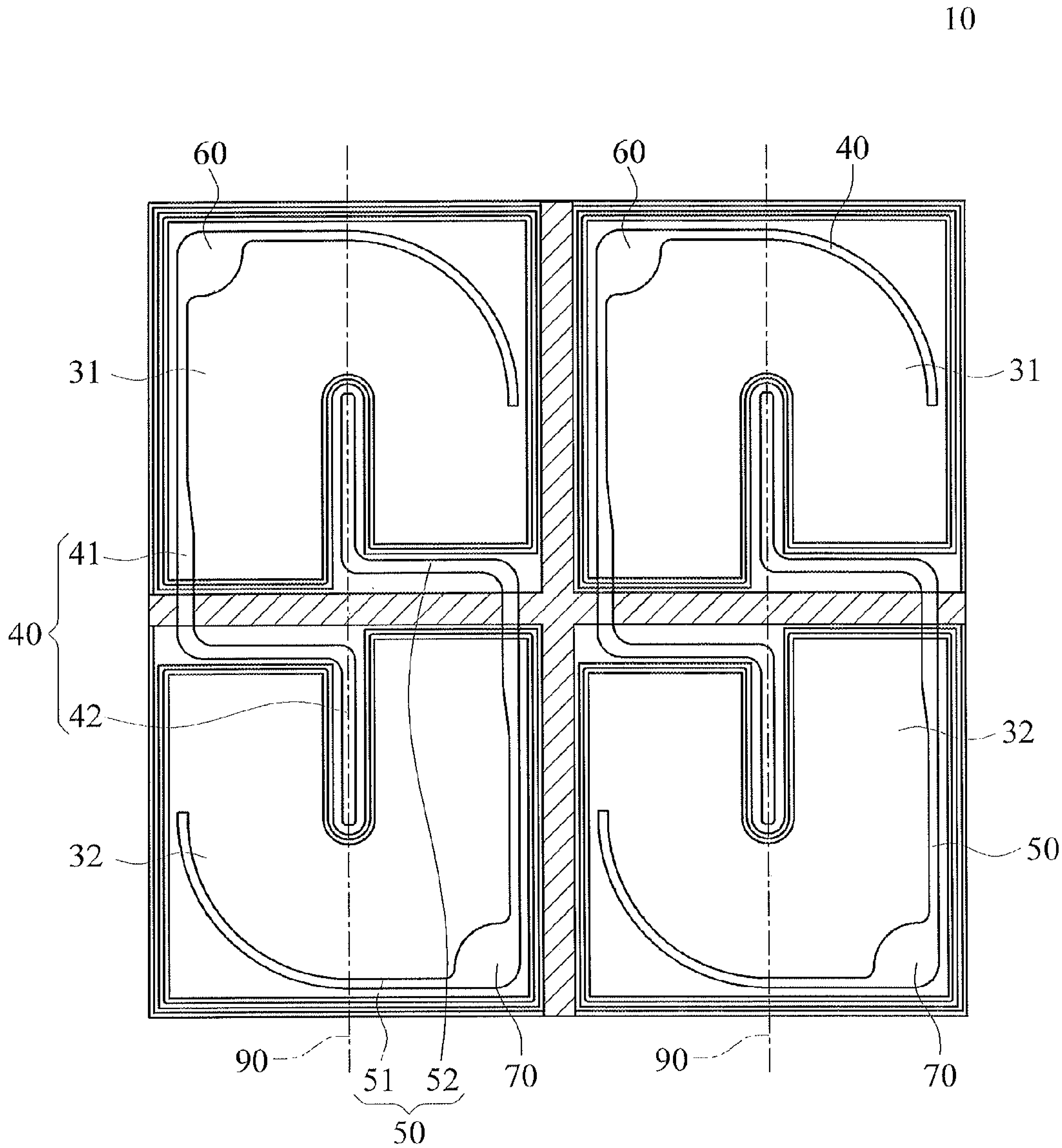


FIG. 9

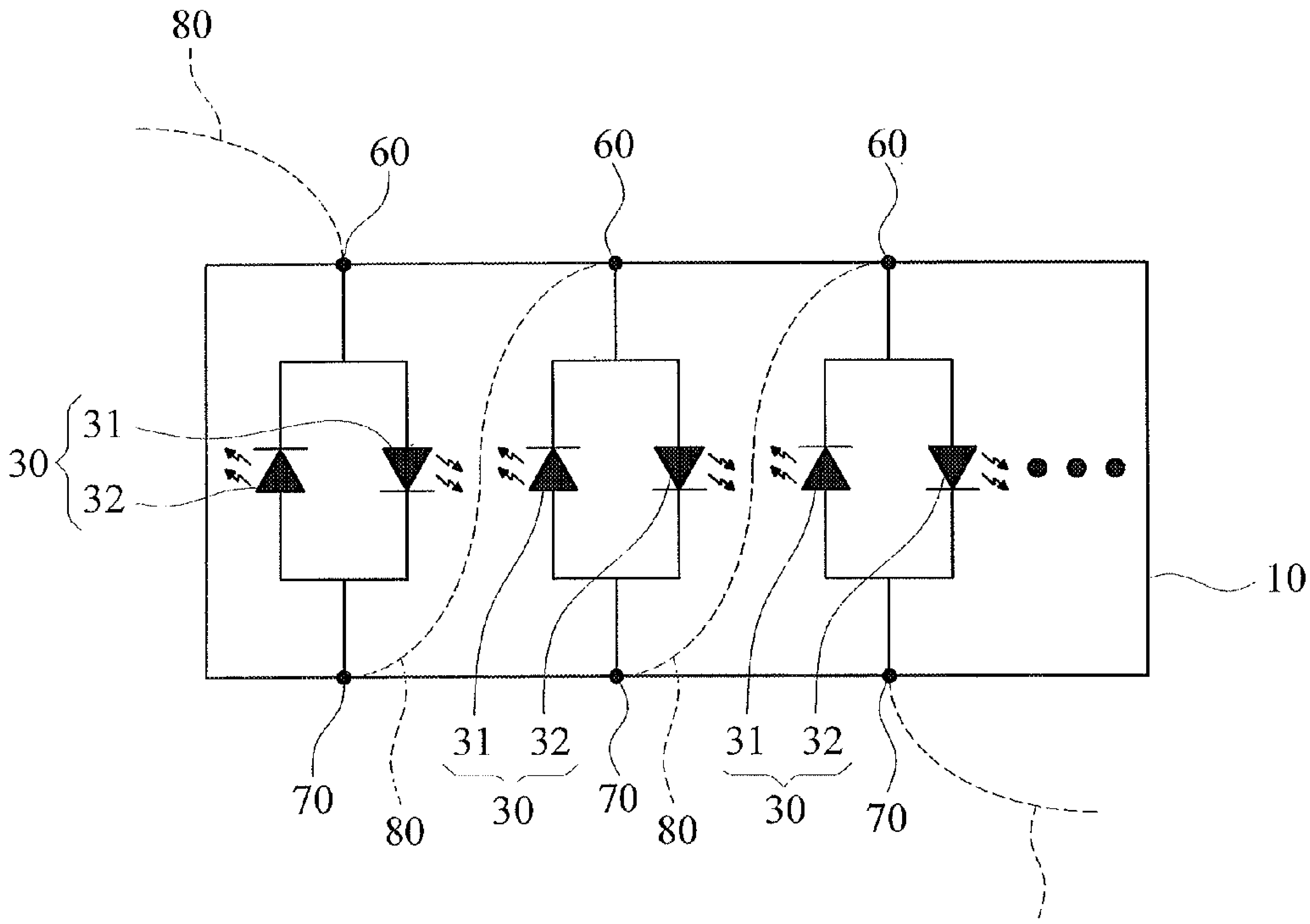


FIG. 10A

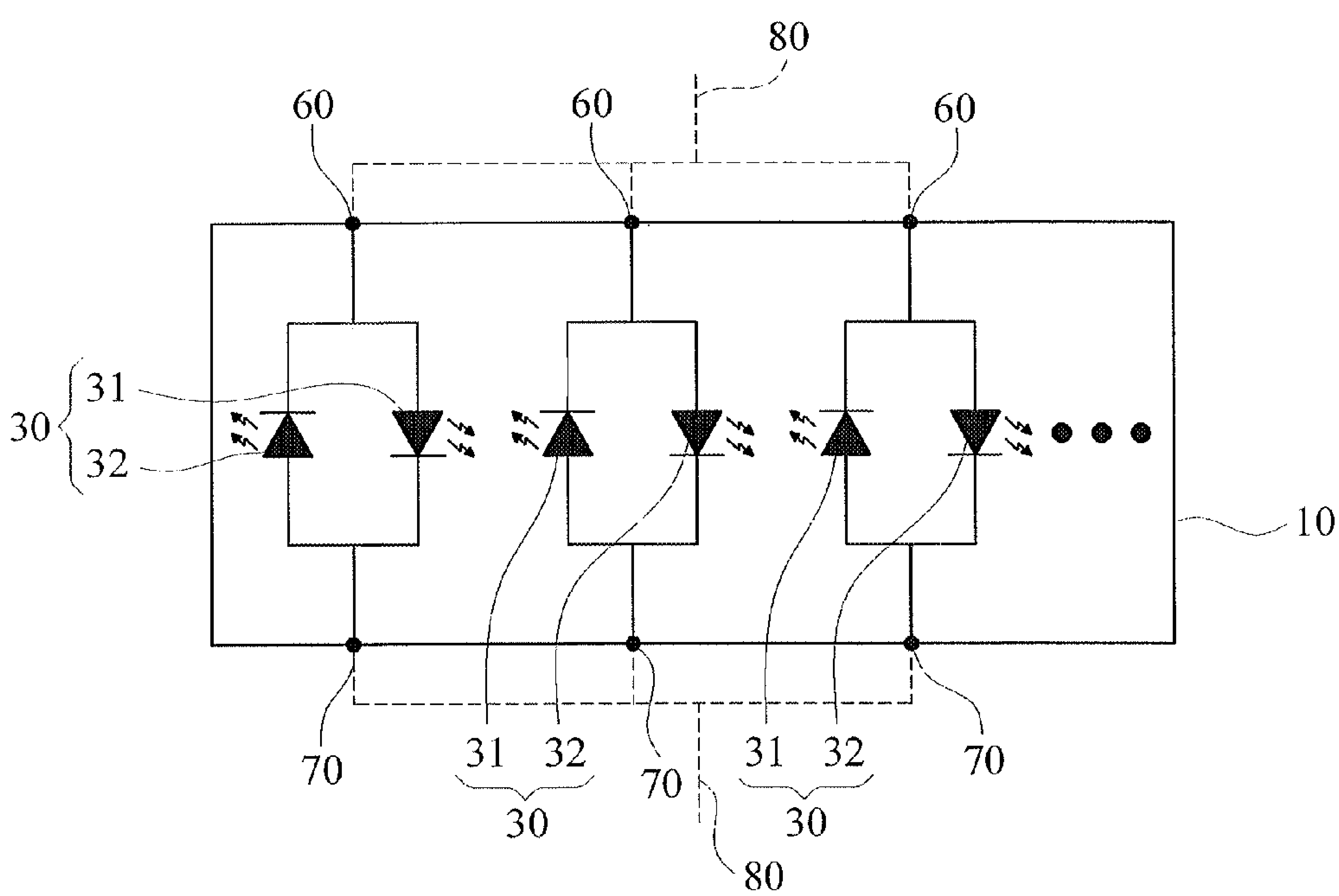


FIG. 10B

HIGH-VOLTAGE AC LED STRUCTURE

BACKGROUND OF THE INVENTION

1. Technical Field

The present invention relates to high-voltage alternating current light-emitting diode (AC LED) structures, and more particularly, to a high-voltage AC LED structure for use in illumination.

2. Description of Related Art

Taiwan utility model patent M393127 discloses an alternating current light-emitting diode device connected to an alternating current power. The alternating current light-emitting diode device essentially comprises four rectifying elements and connects to two pointing elements to thereby form an asymmetrical bridge circuit structure. The alternating current light-emitting diode device further comprises at least two light-emitting diode serial blocks connected to branch circuits of the asymmetrical bridge circuit structure, respectively, such that all or most of the light-emitting diodes of the alternating current light-emitting diode device emit light and thus are brightened up during the positive voltage half cycle and the negative voltage half cycle of an AC power source, thereby enhancing the efficiency of use of the AC power source by the alternating current light-emitting diode device.

Taiwan utility model patent M354294 discloses an alternating current light-emitting device comprising: an AC-AC transformer for converting a first AC voltage supplied by an AC Power source into a second AC voltage; an alternating current light-emitting diode module including a first set light-emitting diode die and a second set light-emitting diode die, wherein electrical conduction of the first set light-emitting diode die is rendered. ON for a first duration during a positive cycle of the second AC voltage, and electrical conduction of the second set light-emitting diode die is rendered ON for a second duration during a negative cycle of the second AC voltage; and a protective unit coupled to between the AC power source and the alternating current light-emitting diode module for providing overvoltage or overcurrent protection.

According to the aforesaid prior art, the light-emitting diodes employed are mostly ordinary diodes manufactured by an ordinary non-wafer level process, and are designed in accordance with the concept of unidirectional or rectifying circuits, or use an AC transformer to perform voltage transformation. With an AC transformer being bulky, the aforesaid method not only renders the whole device bulky too, but also renders the AC transformer power-consuming. Therefore, it is imperative to manufacture a high-voltage alternating current light-emitting diode (AC LED) structure that dispenses with an AC transformer and comprises light-emitting diodes, manufactured by a wafer level process so as to meet market needs.

SUMMARY OF THE INVENTION

The present invention relates to a high-voltage alternating current light-emitting diode (AC LED) structure comprising a circuit substrate and a plurality of AC LED chips. The AC LED chips each comprise an insulated substrate, an LED set, a first metal layer, and a second metal layer. According to the present invention, the AC LED chips manufactured by a wafer level process are coupled to the low-cost circuit substrate to produce a downsized high-voltage AC LED structure.

The present invention provides a high-voltage alternating current light-emitting diode (AC LED) structure, comprising: a circuit substrate; and a plurality of AC LED chips fixed to and electrically connected to the circuit substrate and forming a series-connected circuit by means of the circuit substrate, the AC LED chips each comprising: an insulated substrate; at least one LED set having a first LED and a second LED, wherein the first LED and the second LED are disposed on the insulated substrate and insulated and separated from each other; at least one first metal layer forming a first shape layout and having a first end portion and a second end portion, the first end portion being disposed on a first transparent conductive layer of the first LED, and the second end portion being disposed on a second n-type layer of the second LED; and at least one second metal layer forming the first shape layout and having a third end portion and a fourth end portion, the third end portion being disposed on a second transparent conductive layer of the second LED, and the fourth end portion being disposed on a first n-type layer of the first LED.

Implementation of the present invention at least involves inventive steps as follows:

1. AC LED chips manufactured by a wafer level process are coupled to a low-cost circuit substrate to produce a downsized high-voltage AC LED structure.

2. A high-voltage AC LED structure is produced easily and quickly.

3. A high-voltage AC LED structure that manifests diversity can be produced.

The detailed features and advantages of the present invention will be described in detail with reference to the preferred embodiment so as to enable persons skilled in the art to gain insight into the technical disclosure of the present invention, implement the present invention accordingly, and readily understand the objectives and advantages of the present invention by perusal of the contents disclosed in the specification, the claims, and the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. **1**A is a schematic view of a high-voltage alternating current light-emitting diode (AC LED) structure according to an embodiment of the present invention;

FIG. **1**B is a series-connected equivalent circuit diagram according to an embodiment of the present invention;

FIG. **2**A is a parallel-series connected equivalent circuit diagram in aspect 1 according to an embodiment of the present invention;

FIG. **2**B is a parallel-series connected equivalent circuit diagram in aspect 2 according to an embodiment of the present invention;

FIG. **3** is a perspective exploded view of an AC LED chip according to an embodiment of the present invention;

FIG. **4**A is a perspective assembled view of an AC LED chip according to an embodiment of the present invention;

FIG. **4**B is a top view of an AC LED chip according to an embodiment of the present invention;

FIG. **5** is a cross-sectional view of an AC LED chip taken along line A-A of FIG. **4**A;

FIG. **6** is an equivalent circuit diagram of an AC LED chip according to an embodiment of the present invention;

FIG. **7** is a schematic view of a metal layer with semicircular ends according to an embodiment of the present invention;

FIG. **8** is a schematic view of a metal layer with half S-shaped ends according to an embodiment of the present invention;

FIG. **9** is a schematic view of a metal layer with a layout of another shape According to an embodiment of the present invention;

FIG. **10**A is an equivalent circuit diagram of an AC LED chip in the first application example according to an embodiment of the present invention; and

FIG. **10**B is an equivalent circuit diagram of an AC LED chip in the second application example according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS OF THE INVENTION

Referring to FIG. **1**A, a high-voltage alternating current light-emitting diode (AC LED) structure **100** in this embodiment comprises a circuit substrate **200** and a plurality of AC LED chips **300**.

The circuit substrate **200** is an aluminum substrate or a ceramic substrate. In an embodiment where the AC LED chips **300** are coupled to the circuit substrate **200**, the volume of the circuit substrate **200** is much larger than that of the LED chips **300**; hence, it is feasible to allow the circuit substrate **200** to provide electrical connection for the LED chips **300** and thereby design a diversified parallel-series connected circuit, so as to produce the high-voltage AC LED structure **100** easily, quickly, and diversely.

In addition to circuit connection, the circuit substrate **200** enables heat dissipation. In an embodiment where the circuit substrate **200** is a ceramic substrate, a plurality of thermally conductive posts or a plurality of electrically conductive posts is disposed inside the ceramic substrate for transferring efficiently the heat generated by the AC LED chips **300** in operation and enabling an electrode of the AC LED chips **300** to extend to the other side of ceramic substrate smoothly.

Referring to FIG. **1**B, the plurality of AC LED chips **300** is fixed to and electrically connected to the circuit substrate **200**. AC LED chips **300'** form a series-connected circuit **400** by means of the diverse electrical connection provided by the circuit substrate **200**, thereby finalizing the high-voltage AC LED structure **100**. This is the basic aspect of a series-connected circuit in this embodiment.

Referring to FIG. **2**A and FIG. **2**B, in addition to the aforesaid basic aspect, it is feasible to connect any two of the AC LED chips **300'** in parallel, such that the series-connected circuit **400** further comprises a parallel-connected circuit, or it is feasible for the series-connected circuit **400** to be further parallel-connected with at least one said series-connected circuit **400**, so as to form the high-voltage AC LED structure **100** characterized by diversity.

Referring to FIG. **3** through FIG. **5**, each of the AC LED chips **300** is manufactured by a wafer level process, and each of the AC LED chips **300** comprises an insulated substrate **20**, at least one LED set **30**, at least one first metal layer **40**, and at least one second metal layer **50**. Please refer to FIG. **6** for equivalent circuits **300'** of the AC LED chips.

The insulated substrate **20** is a sapphire substrate or any other insulated substrate applicable to a light-emitting diode process. The insulated substrate **20** is partitioned to form a plurality of regions for carrying the LED sets **30**, respectively.

The LED sets **30** are disposed on the insulated substrate **20**. Each of the LED sets **30** has a first LED **31** and a second LED **32**. The first LED **31** and the second LED **32** are disposed on the insulated substrate **20** and are insulated and separated from each other. The LED sets **30** are insulated and separated from each other. To insulate the first LED **31** and the second LED **32** from each other completely, an insulating layer **33** is disposed between the first LED **31** and the second LED **32**, thereby preventing current leakage.

The first LED **31** comprises a first n-type layer **311**, a first active layer **312**, a first p-type layer **313**, and a first transparent conductive layer **314**. Likewise, the second LED **32** comprises a second n-type layer **321**, a second active layer **322**, a second p-type layer **323**, and a second transparent conductive layer **324**.

The first n-type layer **311** of the first LED **31** is disposed at a first region **21** on the insulated substrate **20**. The second n-type layer **321** of the second LED **32** is disposed at a second region **22** on the insulated substrate **20**. The first region **21** and the second region **22** are adjacent to each other, thereby facilitating electrical connection of the first LED **31** and the second LED **32**.

The first active layer **312** and the second active layer **322**, each of which is U-shaped, meet each other front to front, and are disposed on the first n-type layer **311** and the second n-type layer **321**, respectively, in a manner that portions of the first n-type layer **311** and the second n-type layer **321** are exposed from the first active layer **312** and the second active layer **322**, respectively.

The first p-type layer **313** and the second p-type layer **323** are disposed on the first active layer **312** and the second active layer **322**, respectively. The first transparent conductive layer **314** and the second transparent conductive layer **324** are disposed on the first p-type layer **313** and the second p-type layer **323**, respectively. The insulating layer **33** is disposed on the edges of the first n-type layer **311** and the second n-type layer **321**, such that the first LED **31** and the second LED **32** are completely insulated.

The first metal layer **40** forms a first shape layout and has a first end portion **41** and a second end portion **42**. The first end portion **41** of the first metal layer **40** is disposed on the first transparent conductive layer **314** of the first LED **31**. The second end portion **42** of the first metal layer **40** is disposed on the second n-type layer **321** exposed from the second. LED **32**.

Likewise, the second metal layer **50** forms a first shape layout and corresponds in position to the first metal layer **40**. The second metal layer **50** has a third end portion **51** and a fourth end portion **52**. The third end portion **51** of the second metal layer **50** is disposed on the second transparent conductive layer **324** of the second LED **32**. The fourth end portion **52** of the second metal layer **50** is disposed on the first n-type layer **311** exposed from the first LED **31**. Due to the first metal layer **40** and the second metal layer **50**, not only are the first LED **31** and the second LED **32** electrically connected, but the first LED **31** and the second LED **32** are also connected in parallel and inversely.

To prevent a short circuit which might otherwise develop as a result of electrically connecting the first metal layer **40** to the first LED **31** and the second LED **32**, it is feasible for the insulating layer **33** to extend to the sidewalls of the first LED **31** and the second LED **32**, such that the first LED **31** and the second LED **32** are insulated from the first metal layer **40**. Likewise, a short circuit is likely to occur when the second metal layer **50** is electrically connected to the first LED **31** and the second LED **32**; hence, it is feasible for the insulating layer **33** to extend to the sidewalls of the first LED **31** and the second LED **32**, such that the first LED **31** and the second LED **32** are insulated from the second metal layer **50**.

To enable the AC LED chips **300** to be electrically connected to an external circuit **80**, the AC LED chips **300** further comprises a first solder pad **60** and a second solder pad **70**. The first solder pad **60** is formed on the first end portion **41** of the first metal layer **40**. The second solder pad **70** is formed on the third end portion **51** of the second metal layer **50**. Alternatively, the first solder pad **60** is formed on the second end portion **42** of the first metal layer **40**, whereas the second solder pad **70** is formed on the fourth end portion **52** of the second metal layer **50**.

Hence, it is feasible to electrically connect the external circuit **80** to the first solder pad **60** and the second solder pad **70** and input an AC power for placing the first LED **31** and the second LED **32** in an electrical conduction state. However, for example, once the first LED **31** enter the electrical conduction state, the first end portion **41** of the first metal layer **40** functions as a current emitter, whereas the fourth end portion **52** of the second metal layer **50** functions as a current receiver for receiving the current emitted from the first end portion **41** of the first metal layer **40**, thereby enabling the first LED **31** to emit light.

To enable the first metal layer **40** and the second metal layer **50** to receive a current efficiently and cause the current to diffuse evenly in the first LED **31** and the second LED **32**, the first shape layout formed by the first metal layer **40** and the second metal layer **50** is scooper-shaped, whereas the first metal layer **40** and the second metal layer **50** are disposed at a periphery of the first LED **31** and the second LED **32**, so as to increase the light emission area of the first LED **31** and the second LED **32**.

Furthermore, an end of the second end portion **42** of the first metal layer **40** and an end of the fourth end portion **52** of the second metal layer **50** are disposed at a central axis **90** of the first LED **31** and the second LED **32**, respectively. The distances D between every two adjacent ones of the first metal layers **40** and the second metal layers **50** are equal, such that the distances D for which a current diffuses to the other metal layer are equal. As a result, the current diffuses to the other metal layer at the same speed, and brightens up the first LED **31** and the second LED **32** evenly.

Referring to FIG. **7**, FIG. **8** and FIG. **9** for the following description. The end of the second end portion **42** of the first metal layer **40** and the end of the fourth end portion **52** of the second metal layer **50** are semicircular as shown in FIG. **7**. The first shape layout formed by the first metal layer **40** and the second metal layer **50** is half S-shaped as shown in FIG. **8**. The first shape layout is square, circle, or a combination thereof as shown in FIG. **9**.

Referring to FIG. **10**A and FIG. **10**B, in this embodiment, not only are the LED sets **30** disposed on the insulated substrate **20**, but the external circuit **80** enables the AC LED chips **300** to be connected in series or in parallel, such that the AC LED chips **300** can be subjected to high current density or high-voltage operation as needed. Furthermore, internal connection wires are reduced to eliminate redundancy and reflect necessity; hence, the light emission area of the AC LED chips **300** is not hidden by internal connection wires, thereby enhancing the brightness of the AC LED chips **300**.

The external circuit **80** is either formed by a wire bonding process directly performed on the AC LED chips **300** or formed from a circuit on the circuit substrate **200**, such that the AC LED chips **300** can form a diverse parallel-series connected circuit structure conveniently.

The features of the present invention are disclosed above by the preferred embodiment to allow persons skilled in the art to gain insight into the contents of the present invention and implement the present invention accordingly. The preferred embodiment of the present invention should not be interpreted as restrictive of the scope of present invention. Hence, all equivalent modifications or amendments made to the aforesaid embodiment should fall within the scope of the appended claims.

What is claimed is:

1. A high-voltage alternating current light-emitting diode (AC LED) structure, comprising:
- a circuit substrate; and
- a plurality of AC LED chips fixed to and electrically connected to the circuit substrate and forming a series-connected circuit by means of the circuit substrate, the AC LED chips each comprising:
- an insulated substrate;
- at least one LED set having a first LED and a second LED, wherein the first LED and the second LED are disposed on the insulated substrate and insulated and separated from each other;
- at least one first metal layer forming a first shape layout and having a first end portion and a second end portion, the first end portion being disposed on a first transparent conductive layer of the first LED, and the second end portion being disposed on a second n-type layer of the second LED; and
- at least one second metal layer forming the first shape layout and having a third end portion and a fourth end portion, the third end portion being disposed on a second transparent conductive layer of the second LED, and the fourth end portion being disposed on a first n-type layer of the first LED.

2. The high-voltage AC LED structure of claim **1**, wherein the circuit substrate is an aluminum substrate or a ceramic substrate.

3. The high-voltage AC LED structure of claim **2**, wherein a plurality of thermally conductive posts or a plurality of electrically conductive posts is disposed inside the ceramic substrate.

4. The high-voltage AC LED structure of claim **1**, wherein any two of the AC LED chips are further connected in parallel, such that the series-connected circuit further comprises a parallel-connected circuit.

5. The high-voltage AC LED structure of claim **1**, wherein the series-connected circuit is further parallel-connected to at least one said series-connected circuit.

6. The high-voltage AC LED structure of claim **1**, wherein the first LED comprises the first n-type layer disposed at a first region on the insulated substrate, a first active layer disposed on a portion of the first n-type layer, a first p-type layer disposed on the first active layer, and the first transparent conductive layer disposed on the first p-type layer; and wherein the second LED comprises the second n-type layer disposed at a second region on the insulated substrate, a second active layer disposed on a portion of the second n-type layer, a second p-type layer disposed on the second active layer, and the second transparent conductive layer disposed on the second p-type layer.

7. The high-voltage AC LED structure of claim **6**, wherein the first active layer and the second active layer, each of which is U-shaped, meet each other front to front, and are disposed on the first n-type layer and the second n-type layer, respectively, in a manner that portions of the first n-type layer and the second n-type layer are exposed from the first active layer and the second active layer, respectively.

8. The high-voltage AC LED structure of claim **6**, further comprising an insulating layer disposed on edges of the first n-type layer and the second n-type layer.

9. The high-voltage AC LED structure of claim **8**, wherein the insulating layer extends to sidewalls of the first LED and the second LED.

10. The high-voltage AC LED structure of claim **1**, further comprising a first solder pad and a second solder pad, the first solder pad being formed on the first end portion, and the second solder pad being formed on the third end portion.

11. The high-voltage AC LED structure of claim **1**, further comprising a first solder pad and a second solder pad, the first solder pad being formed on the second end portion, and the second solder pad being formed on the fourth end portion.

12. The high-voltage AC LED structure of claim **1**, wherein the first metal layer and the second metal layer are disposed at a periphery of the first LED and the second LED.

13. The high-voltage AC LED structure of claim **1**, wherein an end of the second end portion and an end of the fourth end portion are disposed at a central axis of the first LED and the second LED, respectively.

* * * * *